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14. ABSTRACT
This TOP provides guidance for preparing test plans and conducting test programs to evaluate the effectiveness and suitability for military use of centrifugal and reciprocating pumps.

15. SUBJECT TERMS
Centrifugal pump
Reciprocating pump
Head
Total discharge head
Total suction head

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US ARMY DEVELOPMENTAL TEST COMMAND
TEST OPERATIONS PROCEDURE

*Test Operations Procedure 09-2-181A 27 April 2011
DTIC AD No.:

PUMPS, CENTRIFUGAL AND RECIPROCATING

*This TOP supersedes TOP 09-2-181, 5 March 1968, and replaces TOP 09-2-182, 11 March 1968.

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1. SCOPE.

The procedures in this Test Operations Procedure (TOP) describe the test methodology and techniques to determine the technical performance and safety characteristics of centrifugal and reciprocating pumps and their associated extended modules and accessories.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

ITEM	REQUIREMENT
Material-handling equipment (MHE)	Offload and load test item from transportation asset.
Maintenance shop	Accomplish Technical Manual (TM) receipt inspection, servicing, inventories, scheduled and unscheduled maintenance, and chamber test preparation.
Climatic chambers	Satisfy the needs of Military -Standard (MIL-STD)-810[1].
Sand and Dust Facility	Satisfy the needs of MIL-STD-810 or a suitable field testing environment.
Rain Test Facility	Satisfy the needs of MIL-STD-810 or a suitable field testing environment.
Automotive road courses	Accomplish road transport durability and reliability road missions.
Reinforced concrete pad	Drop test surface.
Gantry-type crane of suitable load capacity	Means to lift the system for drop and lift and tie-down provision testing.
Quick-release crane hook	Mechanism for release of item for drop testing.
Electromagnetic Interference Test Facility (EMITF)	Satisfy the needs of MIL-STD-461[2].
High-Altitude Electromagnetic Pulse (HEMP) Test Facility	Satisfy the needs of MIL-STD-461.
Rail Impact Test Facility	Satisfy the needs of MIL-STD-810.
Cargo helicopter and approved flight path	Satisfy the needs of MIL-STD-913[3].
Noise Test Facility	Satisfy the needs of TOP 01-2-610[4].
Pressure Chamber	Satisfy the needs of MIL-STD-810.
Fording Basin	Satisfy the needs of TOP 02-2-612[5].
Tilt Table Test Facility	Satisfy the needs of TOP 02-2-002[6].

*Superscript numbers correspond to Appendix D, References.

2.2 Instrumentation.

DEVICE FOR MEASURING	MEASUREMENT ACCURACY
Weight	±1% of reading
Physical dimensions, height (drop tests)	±1 cm (±0.4 in.)
Pressure	±0.25% reading
Ambient or chamber temperature	±2 °C (±3.6 °F)
Relative humidity (RH)	±1% reading
Wind speed	±1 kt
Distance (road)	±0.1 km (±0.1 mi)
Road and rail impact speed	±0.1 km/hr (±0.1 mph)
Surface temperature	±2 °C (±3.6 °F)
Rate of flow	±1.5% reading
Differential head	±1.0% reading
Discharge head	±0.5% reading
Suction head	±0.5% reading
Input power	±1.5% reading
Pump speed	±0.3% reading
Total irradiance	±4% reading or ±15 W/m^2

3. REQUIRED TEST CONDITIONS.

3.1 Planning.

a. Safety. Review the Safety Assessment Report (SAR) and all instructional material issued with the test item by the developer and manufacturer as well as test reports of previous tests conducted on the test item or similar equipment.

b. Requirements. Review the test item's capabilities documents (e.g., Initial Capabilities Document (ICD), Capabilities Development Document (CDD), or Capabilities Production Document (CPD) or Performance Specification (PS)). For acquisition evaluated programs, the System Evaluation Plan (SEP) is the governing document. The SEP will document the methodology and data requirements. For non-acquisition projects, the customer test requirements will be followed based on information provided in the Request for Test Services (RFTS), Statement of Work (SOW), contract documents, and direct communication with the customer. Refer to US Army Developmental Test Command (DTC) PAM 73-1[7], Chapter 4, for additional test planning information.

c. Test Configurations. Test officers should refer to Field Manuals (FMs) 10-52[8] and 10-52-1[9] for water pump and delivery test configuration guidance and FMs 10-67[10] and 10-67-1[11] for petroleum pump and delivery test configuration guidance.

3.2 Test Scheduling.

To provide an early indication of test item suitability, safety-related tests and inspections will be conducted first, followed by physical characteristic measurements to ensure the system configuration requirements are satisfied. Reliability testing will be initiated when the data collection database is established, the test crew is competent in accomplishing all operator- and field-level tasks, and the pumps have completed all break-in time and are operating as intended. In accordance with MIL-STD-810, some environmental tests should be conducted on different test systems to assess the vulnerability against particular environments. For example, humidity testing should not be conducted on the same test item or system that has been subjected to salt fog, sand and dust, or fungus testing.

3.3 Conduct.

a. Scheduled and Unscheduled Maintenance. The test item(s) will be maintained in accordance with the TMs, if available. If maintenance procedures are not available, if the crew does not understand the procedure, or if the crew has difficulty accessing the equipment, the manufacturer will be contacted for further information or guidance.

b. Test Data. For acquisition evaluated programs, all test incidents, maintenance actions, hardware or software modifications, and emerging test results will be recorded in Test Incident Reports (TIRs) in the Repository Information and Test Analysis (RITA) system. Non-evaluated programs can choose to use RITA or the test officer can submit daily/weekly status reports via e-mail or the Versatile Information Systems Integrated On-Line (VISION) Digital Library System (VDLS).

4. TEST PROCEDURES.

4.1 Initial Inspection and Operation.

4.1.1 Method.

a. Upon arrival, the system will be inspected. All applicable protective materials will be removed. Any damage or deterioration resulting from handling, improper packaging, or inadequate preservation will be recorded and photographed. The system will be inspected to identify any obvious defects in workmanship or construction. An initial safety inspection will be conducted to identify potential hazards.

b. The system components, basic issue items (BII), and test support package (TSP) will be inventoried. The inventory will be compared to the packing list or the TM, and all shortages will be identified to the manufacturer and system developer for resolution. If more than one pump is tested simultaneously, each system component will be marked with a test system identification number for tracking purposes. The major component serial numbers and service life (operating time or distance) will be recorded.

c. The pump will be prepared, and an initial service to fuel and lubricate the system will be performed in accordance with the TM or manufacturer’s instructions, and the consumable amounts will be recorded.

d. The pump will be operated as intended (either with assistance from the manufacturer or after operator training) to verify that it is fully functional. All faults will be identified and recorded. Any corrective actions and replacement parts required to repair the pump will be recorded. A noise survey will be performed at the operator and maintainer's position to identify where 85 dB(A) is exceeded. The test site will be marked for the noise contour, and the test crew will be equipped with the appropriate hearing protection. This noise survey may not constitute the official noise contour test (paragraph 4.5.1a) if the test site is not configured in accordance with the test procedure (on gravel pad, multiple systems operating, or reflective surfaces prevalent). The survey will serve to protect test personnel and visitors at the test and training site.

4.1.2 Data Required.

a. Receipt condition of the test system.

b. Photographs of any damage or deformation attributed to transport.

c. Test system, BII, or TSP inventory shortages.

d. Manufacturer, model, and serial numbers and service life of all major components.

e. Safety inspection and noise survey results.

f. Break-in or initial operation check results.

4.1.3 Data Presentation.

The receipt condition and initial operation of the test system will be summarized in a paragraph or summary tables supported by photographs. Inventory shortages and if the shortages were reconciled before testing will be recorded. Results of the safety inspection in paragraph 4.4, noise survey in paragraph 4.5, and human factors engineering (HFE) will be recorded. Modifications performed to correct potential hazards or reduced noise levels during testing will be recorded.

4.2 Operator and Maintainer Training.

4.2.1 Method.

a. The schedule, environment (classroom or field), and duration of training will be coordinated with the manufacturer or representative responsible for training. The facilities and personnel will be scheduled as required. Trainers will instruct the test team in the capabilities, assembly, operating and maintenance procedures, disassembly, and storage of the system.

b. Test crew members will be requested to complete a Test Participant Demographic Data Form (Appendix A, Form A-1) to document their current position/rank, experience, and previous training.

c. The crew, support personnel, and manufacturer's technical representatives will be provided an overview of the test requirements, administration and site security procedures, and test schedule. A risk assessment and job hazard analyses (JHAs) will be prepared for reading and signature, and a copy of both will be posted at the test site. A copy of all applicable Material Safety Data Sheets (MSDSs) will be provided for review and posted at the test site. General test facility hazards and safety precautions will be reviewed.

d. The adequacy and completeness of the TMs and/or other instructional materials used for training purposes will be recorded. After new equipment training (NET), test personnel will complete a NET questionnaire (Appendix A, Form A-2). All hardware or software incidents, maintenance performed, parts replaced to repair the pump during training will be recorded.

4.2.2 Data Required.

a. Test Participant Demographic Data Forms (Appendix A, Form A-1).

b. NET questionnaires (Appendix A, Form A-2).

c. Incident documentation (TIR or status report as described in paragraph 3.3b).

d. TM or training instruction inadequacies and comments.

4.2.3 Data Presentation.

Each respondent will be assigned a numerical code. Demographic data forms and NET questionnaires will be summarized in tables. TM or training inadequacies will be summarized in a table.

4.3 Physical Configuration.

The physical characteristics, center of gravity (CG), and weight distribution of the test item, in each pump stowage and transport configuration (e.g., skid, trailer-mounted or storage container), will be measured as in accordance with TOPs 01-2-504[12], 02-2-800[13], and 02-2-801[14].

4.4 Safety.

General guidance for system safety analysis is provided in TOP 01-1-060[15].

4.4.1 Method.

a. SAR Review. Personnel will review the SAR to identify all developer- or contractor-identified safety and health hazards. The hazards and means of mitigation identified in the SAR will be verified during the operator/maintainer test team training when the TMs are received.

b. Inspection and Operation. A system-specific hazards checklist derived from TOP 10-2-508[16] will be completed during the safety inspection. Representative surface temperatures will be measured using a contact or infrared temperature measurement device to

identify if any thermal contact hazards exist. Temperatures will be compared to the temperature exposure limits in MIL-STD-1472F[17], Table XXI. Moving and rotating parts will be checked for the presence of guards. Warning placards will be checked for appropriate location, security, content, format, and readability. All safety-related incidents or concerns will be reported, and physical configuration safety hazards will be photographed.

c. Safety Devices and Equipment. The types, locations, and rating/certifications for safety and warning devices on the system will be recorded. The adequacy and functionality of the devices will be verified, to the maximum extent possible, without causing harm to the item. For example, pressure relief valves will be inspected to determine if they discharge down and away from personnel occupied areas. The type, size, storage location, and means of positive securement of the fire extinguisher will be recorded.

d. Noise. Noise testing is addressed in paragraph 4.5.

e. Petroleum, oils, and lubricants (POL). During petroleum pump testing and POL handling operations, safety precautions, as specified in FM 10-67-1, Chapter 2, will be observed.

4.4.2 Data Required.

a. SAR.

b. Inspection and Operation.

(1) Safety hazards checklist.

(2) Safety- or health-related incidents or concerns.

(3) Adequacy of safety instructions in the TMs.

(4) Results of the physical inspection of the system verifying the provision of warning or caution placards as listed in the SAR and/or TM.

(5) Photographs of safety-related physical configuration concerns.

c. Safety Devices and Equipment.

(1) Identification (type and purpose) of safety and warning devices.

(2) Methods and results (suitability, adequacy, proper operation, and malfunctions) of safety/warning device tests.

(3) Recommendations for additional or improved safety or warning devices.

4.4.3 Data Presentation.

Potential safety hazards will be summarized in a table. If the system is being evaluated, the hazards will be classified for hazard probability and severity in accordance with Department of Army Pamphlet (DA Pam) 385-16[18]. Recommendations to mitigate the hazard(s) will be made. Results of the safety device and equipment inspections and tests will be summarized in paragraph or tabular form. Recommendations will be made to improve the safety devices, warning/caution placards, and TM procedures.

4.5 Human Factors Engineering (HFE).

4.5.1 Method.

a. Sound Level Measurements, TOP 01-2-610, paragraph 5.2. The 85-dB(A) contour(s) and peak noise levels will be recorded at all operator and maintainer personnel occupied areas with the system assembled and operated in accordance with the TM. At a minimum, the system should be operated at its highest pressure/flow rating to capture the most significant noise signature. If time permits, testing noise levels should be recorded with the system operating at various settings.

b. Workspace and Anthropometrics, TOP 01-2-610, paragraph 5.6. Anthropometric and static strength data will be measured and recorded for each system operator and maintainer. The required number of test personnel will be used to assemble and operate the system. Any difficulties performing the required tasks or accessing specific controls or equipment for operation or maintenance will be recorded.

c. HFE Design. Control types will be identified, and control separation and dimensions will be measured and recorded. If applicable, or of concern, force/torque measurements will be performed in accordance with TOP 01-2-610, paragraph 5.7. Crew members will don cold-wet gloves and mission-oriented protective posture (MOPP) IV gloves and perform representative operator-level tasks to determine if the control design and layout are conducive to efficient operations in all mission environments. System-specific HFE questionnaires will be developed and administered to all test personnel to rate the adequacy, ease of performance, intensity, and maintainability of the system.

4.5.2 Data Required.

a. Sound Level.

(1) System identification and configuration.

(2) List of calibrated instrumentation (nomenclature, model and serial numbers, manufacturer, and manufacture and calibration dates).

(3) Date, location, air temperature, RH, wind speed, and background noise level.

(4) Steady-state noise contour(s), 85 dB(A).

(5) Noise levels at the operator and maintainer's positions.

b. Workspace and Anthropometrics.

(1) Anthropometric and static strength data.

(2) Workspace concerns, supported by photographs or measurements.

c. HFE Design.

(1) Controls and display identification.

(2) Measurements of controls and control separation.

(3) Operator's comments regarding ease or difficulty performing system tasks while wearing cold-wet or MOPP gloves.

(4) HFE questionnaires.

4.5.3 Data Presentation.

Steady-state noise data will be summarized in tables and compared to the limits for personnel occupied areas listed in MIL-STD-1474D[19], Tables 1 and 2, and the PS. The noise contour(s) will be illustrated graphically over a top view of the system configuration. Anthropometric and static strength data will be compared to standard percentile charts, and a percentile rating will be assigned for each measurement. Control and display data and the lifting handles of manually handled components will be compared to the recommended and preferred design criteria values in MIL-STD-1472F. HFE questionnaires will be summarized in tables. Comments from the crew member will be summarized in paragraphs or tables.

4.6 Environmental Effects.

Environmental tests include several areas such as simulated climatic chamber tests, natural environments, and shock and vibration. For the purpose of this TOP, shock and vibration tests are addressed in paragraph 4.8. MIL-STD-810G is the primary reference for the test methods. The test fluid employed for most tests are temporary, and the quality and temperature of the source must be monitored so as not to degrade the operation of the test system or equipment.

4.6.1 Low Temperature.

Testing pumps and equipment at temperatures below 0 °C (32 °F) creates challenges. Proper drainage of all test system pumps, hoses, hardware, and tanks is critical before exposure to low temperature environments. If water is being used while testing in a climatic chamber, the water must be stored outside the chamber and either employed with system hoses directed through

available openings in the chamber walls or relocated inside the chamber before pump operation. Water temperatures ranging from 2 °to 4 °C (35 to 40 °F) are desired for the test to simulate a natural source. If testing with a fuel or oil-type fluid, the fluid may be placed inside the climatic chamber.

4.6.1.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded. All components will be inspected to determine if they are equipped with drain valves. The drain valves will be inspected to determine if they are positioned as low as possible to facilitate proper drainage. Thermocouples will be positioned in the chamber at the fluid source and on critical pump parts.

b. Storage. The test system and engine will be prepared for low temperature testing in accordance with the TM. The pump will be positioned in the climatic chamber in the stored configuration. Storage testing will be performed in accordance with MIL-STD-810G, Test Method 502.5, Procedure I, for a minimum of 24 hr after temperature stabilization. The chamber temperature will be increased to ambient, the components and subsystems will be visually inspected, and the pump will be functionally checked. Results of the functional check will be compared to the pretest data.

c. Operation and Manipulation. MIL-STD-810G, Test Method 502.5, Procedure II, operation, will be conducted. After system stabilization at the low operating temperature, MIL-STD-810G, Procedure III, manipulation, will be performed. The test system will be assembled in accordance with the TM. The hoses will be directed to and from the test fluid source tank. The pump will be operated in accordance with the TM. Difficulties experienced by the test crew in manipulating or engaging the pump hardware or controls with cold weather gloves will be recorded. The test team will follow the flow of fluid through the pump to ensure that all components and subsystems are fully functional and no significant leaks are experienced. If not specified in the PS, the pump will be operated for a minimum of 4 hr. System operating data will be recorded at least hourly. After the operational test, the pump will be deactivated and drained in accordance with the TM. The chamber temperature will be increased to standard ambient. All pump components and hardware will be visually inspected to determine if any low temperature degradation or damage was experienced.

4.6.1.2 Data Required.

a. Test pump identification.

b. Pretest functional check results.

c. Low temperature preparation or servicing.

d. Post-test low temperature storage visual inspection and functional test results.

e. Cold start procedures.

f. Chamber, test fluid, and system temperature time histories.

g. Test system operating data (Appendix A, Form A-3).

h. Malfunctions, deformation or leakage during pump operation (TIRs).

i. Comments regarding the employment of cold weather waterproof gloves.

4.6.1.3 Data Presentation.

System operating data will be presented in a table. Temperature time histories will be summarized in tables or presented as graphs. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.6.2 High Temperature.

Testing pumps and equipment at high temperatures creates challenges. If employing a climatic chamber, the test fluid should be stored outside the chamber and either employed with system hoses directed through available openings in the chamber walls or relocated inside the chamber and routed through a powered chiller to prevent the fluid from exceeding the limitation of operation specified in the TM. The physical space available in the climatic chamber may limit the quantity of hardware items that can be tested. For example, installing short or single sections of hose between pumps and subsystems is encouraged.

4.6.2.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded.

b. Storage. The test pump and engine will be prepared for high temperature testing in accordance with the TM. The pump will be positioned in the climatic chamber in the stored configuration. Storage testing will be performed in accordance with MIL-STD-810G, Test Method 501.5, Procedure I, for a minimum of 24 hr after temperature stabilization. The chamber temperature will be decreased to ambient, the components and subsystems will be visually inspected, and the pump will be functionally checked. Results of the functional test will be compared to the pretest data.

c. Operation and Manipulation. MIL-STD-810G, Test Method 501.5, Procedure II, operation, will be conducted. After the pump stabilizes at the high operating temperature, MIL-STD-810G, Procedure III, manipulation will be performed. The test system will be assembled in accordance with the TM. The hoses will be directed to and from the test fluid source tank. The pump will be operated in accordance with the TM. Difficulties experienced by the test crew in manipulating or engaging the pump hardware or controls will be recorded. The test team will follow the flow of fluid through the pump to ensure that all components and subsystems are fully functional and no significant leaks are experienced. If not specified in the PS, the pump will be operated for a minimum of 4 hr. System operating data will be recorded at

least hourly. After the operational test, the pump will be deactivated and drained in accordance with the TM. The chamber temperature will be decreased to standard ambient. All pump components and hardware will be visually inspected to determine if any high temperature degradation or damage was experienced.

4.6.2.2 Data Required.

a. Test pump identification.

b. Pretest functional check results.

c. High temperature preparation or servicing.

d. Post-test high temperature storage visual inspection results.

e. Chamber, test fluid, and pump temperature time histories.

f. Test system operating data (Appendix A, Form A-3).

g. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.2.3 Data Presentation.

System operating data will be presented in a table. Temperature time histories will be summarized in tables or presented in graphs. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.6.3 Humidity.

If employing a climatic chamber, the test fluid must be stored outside the chamber and either employed with system hoses directed through available openings in the chamber walls or relocated inside the chamber before pump operation. MIL-STD-810G, Test Method 507.5, paragraph 2.1.2, provides test sequence guidance.

4.6.3.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded. The pump will be visually inspected, and any existing corrosion will be recorded and photographed.

b. The pump will be positioned in the climatic chamber in the operational configuration. Aggravated testing will be performed in accordance with MIL-STD-810G, Test Method 507.5, Procedure II. A 24-hr conditioning cycle will be performed followed by a minimum of ten cycles of the aggravated test cycle. The pump will be subjected to an operational check after every five cycles. If not specified in the PS, the pump will be operated for a minimum of 2 hr. System operating data will be recorded at least hourly.

c. After humidity exposure, the pump will be visually inspected. Any corrosion or material degradation will be recorded. A post-test functional or operational check test will be performed, and the results will be recorded.

4.6.3.2 Data Required.

a. Test system identification.

b. Pretest functional check results.

c. Pretest visual inspection results.

d. Chamber temperature and humidity time histories.

e. Test system operating data (Appendix A, Form A-3).

f. Malfunctions, deformation, or leakage during system operation (TIRs).

g. Post-test visual inspection results.

4.6.3.3 Data Presentation.

System operating data will be presented in a table. Temperature and humidity time histories will be summarized in tables or in a graph. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables. Corrosion will be classified in accordance with the U.S. Army TACOM Life Cycle Management Command (TACOM LCMC) Corrosion Rating System[20].

4.6.4 Salt Fog.

Test sequence guidance is provided in MIL-STD-810G, Test Method 509.5, paragraph 2.1.2.

4.6.4.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded. The pump will be visually inspected, and any existing corrosion will be recorded and photographed.

b. The pump will be positioned in the salt fog chamber in the operational configuration. Testing will be performed in accordance with MIL-STD-810G, Test Method 509.5. After testing, the pump will be removed from the chamber, rinsed with water, and visually inspected. Any corrosion will be recorded and photographed.

c. The pump will be assembled at the test site, a functional or operational check test will be performed, and the results will be recorded.

4.6.4.2 Data Required.

a. Test system identification.

b. Pretest functional check results.

c. Pretest visual inspection results.

d. Chamber temperature, salt-fog potential of hydrogen (pH), and fallout rate time histories.

e. Post-test visual inspection results.

f. Output flow rate and totalizer volume.

g. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.4.3 Data Presentation.

System operating data will be presented in a table. Inspection and operating results documented in TIRs will be summarized in paragraphs or tables. Corrosion will be classified in accordance with the TACOM LCMC Corrosion Rating System.

4.6.5 Fungus.

Test sequence guidance is provided in MIL-STD-810G, Test Method 508.6, paragraph 2.1.2. Recommend to the U.S. Army Test and Evaluation Command (ATEC) System Team (AST) that the test system manufacturer develop a list of all component and subsystem materials. The materials should be compared to the fungus-inert and fungus nutrient lists in MIL-STD-810G, Test Method 508.6, Annex B. Manufacturer-specific brand names should be researched to determine the common terminology or constituents. Materials listed on the fungus nutrient list that have been treated will require identification of the treatment method. Those materials not certified as fungus-inert, or are treated fungus nutrient materials, should be submitted for laboratory testing. Material samples can be submitted in lieu of the entire component (i.e., a 10- to 12-in. sample of hose material could be submitted in place of a 50-ft hose line).

4.6.5.1 Method.

a. Testing will be performed in accordance with MIL-STD-810G, Test Method 508.6. If the test duration is not included in the PS, a minimum duration of 28 days (desire 84 days) should be employed.

b. Immediately after testing, the test item(s) will be visually inspected, and the results will be recorded.

4.6.5.2 Data Required.

a. Test material and component identification and condition (new or used).

b. Pretest cleaning performed, if any.

c. Species of fungus grown and inoculated on the cotton control strips and test item material samples.

d. Chamber temperature and humidity time histories.

e. Test duration, days.

f. Post-test visual inspection and/or functional check results in accordance with MIL-STD-810G, Test Method 508.6.

g. Test system operating data (Appendix A, Form A-3), if applicable.

h. Malfunctions, deformation, or leakage during system operation (TIRs), if applicable.

4.6.5.3 Data Presentation.

The components and materials used during testing will be presented in a table. The test procedure and inspection results will be summarized in paragraphs or tables. System operating data will be presented in a table. Operating results documented in TIRs will be summarized in paragraphs or tables.

4.6.6 Blowing Rain.

4.6.6.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded. Lubricant reservoirs (engine oil) will be sampled.

b. The pump will be positioned at the Rain Test Facility in the operational configuration. The pump will be operated in a closed loop with the test liquid in a storage tank. Fuel should be used in lieu of water for this subtest, if applicable. Testing will be performed in accordance with MIL-STD-810G, Test Method 506.5, Procedure I. If not specified in the PS for the pump, the rainfall rate will be 1.7 mm/min (4 in./hr), and the wind speed will be 18 m/s (40 mph). After each side of the pump is exposed to blowing rain, the pump will be inspected, and operating data will be recorded. All instruments and pressure/temperature/flow measuring devices will be inspected to determine if they were degraded. Electrical control panels, if applicable, will be inspected for water intrusion. Fluid reservoirs (engine oil, fuel source) will be sampled before and after testing, and the samples will be submitted to a chemistry laboratory for water analysis.

4.6.6.2 Data Required.

a. Test system identification and orientation.

b. Pretest functional check results.

c. Ambient temperature and wind speed.

d. Side of test system exposed and duration.

e. Rainfall rate and wind speed.

f. Post-test visual inspection results.

g. Test system operating data (Appendix A, Form A-3).

h. Lubricant water analysis results.

i. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.6.3 Data Presentation.

System operating and test fuel data will be presented in a table. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.6.7 Blowing Sand and Dust.

Test sequence guidance is provided in MIL-STD-810G, Test Method 510.5, paragraph 2.1.2. Guidance for sand and dust tests conducted at an outdoor facility is provided in TOP 01-2-621[21].

4.6.7.1 Method.

a. A pretest functional or operational check test will be conducted to baseline the pump. All nonfunctional components or subsystems should be repaired or recorded.

b. Blowing Sand. The pump will be positioned at the Sand and Dust Test Facility in the operational configuration. The pump will be operated in a closed loop with the test fluid storage tank. Testing will be performed in accordance with MIL-STD-810G, Test Method 510.5, Procedure II. If not specified in the PS for the pump, the sand concentration will be 1.1 ± 0.3 g/m^3 (for material used or stored unprotected near operating surface vehicles), and the wind speed will be 18 ± 1.3 m/s (40 ± 3 mph). After each side of the pump is exposed to blowing sand, the pump will be inspected, and operating data will be recorded. Particular attention will be given to engine inlet air filters to determine when the filters are saturated and require cleaning or replacement. All equipment, instruments, and pressure/temperature/flow measuring devices will be inspected to determine if they were degraded.

c. Blowing Dust. The pump will be positioned at the Sand and Dust Test Facility in the operational configuration. The pump will be operated in a closed loop. Testing will be performed in accordance with MIL-STD-810G, Test Method 510.5, Procedure I. If not specified in the PS for the pump, the dust concentration will be 10.6 $\pm$ 7 g/m^3, and the wind speed will be 8.9 $\pm$ 1.3 m/s (20 $\pm$ 3 mph). After each side of the pump is exposed to blowing dust, the pump will be inspected, and operating data will be recorded. Particular attention will be given to engine inlet air filters to determine when the filters are saturated and require cleaning or replacement. All equipment, instruments, and pressure/temperature/flow measuring devices will be inspected to determine if they were degraded.

4.6.7.2 Data Required.

a. Test system identification and orientation.

b. Pretest functional check results.

c. Ambient temperature, humidity, and wind speed.

d. Side of test system exposed and duration.

e. Wind speed and sand/dust concentration.

f. Post-test visual inspection results.

g. Test system operating data (Appendix A, Form A-3).

h. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.7.3 Data Presentation.

System operating and source water data will be presented in a table. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.6.8 Solar Radiation.

4.6.8.1 Method.

a. The pump will be positioned in the solar radiation chamber in the operational configuration. Based on the requirements document, the pump may or may not be operated during the test. Testing will be performed in accordance with MIL-STD-810G, Test Method 505.5. Procedure I (heating effects) will be employed if a procedure is not identified in the specification.

b. If the pump is not to be operated during testing, a pretest operational check test will be performed.

c. After testing, the pump will be visually inspected, and if applicable, an operational check test will be performed to evaluate any system degradation.

4.6.8.2 Data Required.

a. Test system identification and orientation.

b. Pretest and post-test operational check results, if applicable.

c. Test item response temperatures, and humidity if required, and number of diurnal cycles or exposure periods.

d. Temperature sensor locations on the test item.

e. Test system operating data (Appendix A, Form A-3).

f. Spectral power distribution of the source lighting and solar lamp bank identification.

g. Solar sensor location and distance from solar light bank.

h. Malfunctions, deformation, or leakage during system operation (TIRs).

i. Chamber, solar, and test item temperature time histories.

4.6.8.3 Data Presentation.

System operating data will be presented in a table. Post-test operational check test results will be presented in paragraphs or a table. Temperature time histories will be summarized in tables or presented as graphs.

4.6.9 Altitude (Low Pressure).

4.6.9.1 Method.

a. Testing will be performed in accordance with MIL-STD-810G, Test Method 500.5. Unless otherwise specified in the manufacturers performance specification only test procedures I, storage/air transport, and procedure II, operation/air carriage are necessary.

b. After testing, the pump will be subjected to a visual inspection and an operational check test at ambient conditions.

4.6.9.2 Data Required.

a. Test system identification.

b. Pretest and post-test functional check results.

c. Test altitude and corresponding pressure.

d. Test temperature.

e. Test duration.

f. Altitude change rates.

g. Test system operating data (Appendix A, Form A-3).

h. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.9.3 Data Presentation.

Test temperature, altitude change rates, test duration, and test altitude, and pressure will be recorded in a table. Functional check results recorded in TIRs will be presented in paragraphs or a table.

4.6.10 Transit Drop (Skid-mounted Pumps).

4.6.10.1 Method.

a. Testing will be performed in accordance with MIL-STD-810G, Test Method 516.6, procedure IV, transit drop. The number of drops, height of each drop, and system configuration/contact is defined in Table 516.6-VI based on the weight of largest dimension of the test item. The actual number of drops and orientations may be reduced from the required 26 for items weighing less than 100 lb based on the PS, the limited number of test samples, or by informed discussions at the In-Process Review (IPR) or test planning meetings.

b. After testing the pump will be visually inspected and a post-test operational check test will be performed to evaluate system degradation.

4.6.10.2 Data Required.

a. Test system identification.

b. System orientation and drop height.

c. Pretest and post-test visual inspection results.

d. Post-test damage photographs.

e. Test system operating data (Appendix A, Form A-3).

f. Malfunctions, deformation, or leakage during system operation (TIRs).

4.6.10.3 Data Presentation.

System orientation, drop height, and post-test physical inspection results will be recorded in TIRs and summarized in a table. Photographs documenting the post-test inspections will support the written decsriptions. The post-test operational check test results will be presented in paragraphs or a table.

4.7 Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) (if applicable).

4.7.1 Method.

a. As listed in TOP 06-2-542[22] (EMI) and 01-2-511[23] (EMC), specific radiated and conducted emissions and susceptibility tests will be performed in accordance with the PS and MIL-STD-461E.

b. The pump will be operated in a closed loop with a large water source in the EMITF. The source temperature will be monitored, and the water will be exchanged or conditioned with a powered chiller so the pump does not exceed the maximum operating temperature specified in the TM.

c. System operating data will be recorded during all tests that permit personnel in the chamber. Otherwise, the pump will be monitored remotely by cameras focused on the control panel or specific engine or system instruments to determine if the system operation has been degraded.

4.7.2 Data Required.

a. As listed in TOP 06-2-542 (EMI) and 06-2-560 (EMC).

b. System identification and test configuration.

c. Output flow rate.

d. Physical inspection results

e. Repairs or maintenance performed to restore the pump to a fully functional state, recorded in TIRs.

4.7.3 Data Presentation.

a. As listed in TOP 06-2-542 (EMI) and 06-2-560 (EMC).

b. Pump operating data will be presented in a table. The inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.8 Automotive Performance (Trailer-Mounted).

a. As listed in TOP 01-2-500[24], plan to test each of the pump stowage and transport configurations (i.e., truck, trailer, container). If the test system is within the gross weight and CG parameters of previously tested systems transported in/on type-classified trucks and trailers, a majority of the safety-related road testing (i.e., braking, steering and handling, etc.) will not require repeating. If the road march profile is not included in the Operational Mode Summary/Mission Profile (OMS/MP) for the pump, the designated transport truck or trailer profile should be used.

b. After all shock and vibration tests (rail impact, road, airdrop), an operational check test will be performed to determine if the pump operability has been compromised.

4.8.1 Static Rollover Threshold (Tilt Table).

Testing will be performed in accordance with TOP 02-2-002 and Society of Automotive Engineers (SAE) J2180[25].

4.8.2 Steering and Handling.

Testing will be performed in accordance with TOP 02-2-002. The tow vehicle and trailer combination will be operated in its minimum turning diameter to determine if there is sufficient clearance between the trailer-mounted test item and the tow vehicle(s). An emergency lane-change test will be performed to determine if the trailer remains stable behind each designated tow vehicle.

4.8.3 Braking.

Testing will be performed in accordance with TOP 02-2-608[26.] It is crucial, for safety reasons, to ensure that the trailer-mounted test item does not have any negative effects on the tow vehicle and that the trailer remains stable during emergency braking maneuvers.

4.8.4 Gradeability and Side Slope Mobility.

Testing will be performed in accordance with TOP 02-2-610[27] for longitudinal grade and side slope performance.

4.8.5 Fording.

Testing will be performed in accordance with TOP 02-2-612 at the shallow water fording depth identified in the PS (typically 36-in.). Each fluid reservoir below the water fording depth will be sampled before and after testing and analyzed for water contamination.

4.9 Transportability (Trailer-Mounted and Container Configurations).

Testing will be performed in accordance with TOP 01-2-500. Each pump stowage and transport configuration (i.e., trailer or container) will be tested. If the road march profile is not included in the OMS/MP for the system, the designated transport truck or trailer profile should be used. An operational check test will be performed after all shock and vibration tests (rail impact, road, airdrop) to determine if pump operation has been compromised.

4.10 Reliability and Durability.

4.10.1 Method.

a. The reliability test will be conducted in accordance with the OMS/MP and within the capabilities of the test center. To reduce the overall test duration, reliability tests of pumps are operated on a 20- or 24-hr basis, requiring the scheduling of multiple shifts. The systems are tested in a closed loop with a large fluid reservoir. If the reservoir is limited in volume, as with fuel tanks, the fluid temperature will be monitored so as the maximum operating temperature specified in the TM is not exceeded. The pumps will be operated in accordance with the TM, torn down, skid-mounted units will be loaded onto a vehicle or trailer, driven a specific distance or time period (in accordance with the OMS/MP), and the procedure will be repeated for the required number of hours identified in the PS or SEP. All test incidents will be recorded in TIRS. The TIR system operating parameters typically include system operating hours, total fluid displaced, number of setups and teardowns, and vehicle and trailer miles when applicable.

b. A fluid totalizer and flowmeter will be installed to record the output flow rate and system life. System operating data are recorded on an hourly basis.

4.10.2 Data Required.

a. As listed in TOP 01-1-030[28] (TIRs).

b. System identification and test configuration.

c. Output flow rate.

d. Operating time (hr) and other pump operating parameters (i.e. oil pressure, etc.).

e. Physical inspection results.

f. Repairs or maintenance performed to restore the pump to a fully functional state, record in TIRs.

4.10.3 Data Presentation.

a. As listed in TOP 01-1-030.

b. The system operating data will be presented in tables and graphs.

4.11 Integrated Logistics Support (ILS).

ILS refers to the materiel and services required to enable the operating forces to operate, maintain, and repair the end item within the maintenance concept defined. For test programs, ILS encompasses test personnel training, repair parts, support equipment, technical publications, and contractor engineering and technical services. The criteria assessed include maintainability, self-sustained operation, engine fuel compatibility, military lubricants, replacement part compatibility and provisions, water/fuel storage and supply equipment interfaces, procedures and tools, operation time meter, and monitoring instrumentation. Testing, inspections and analysis will be performed in accordance with TOP 01-1-030.

4.12 Hydrostatic.

The objective of this test is to demonstrate that the pump will not leak or fail structurally when subjected to required hydrostatic pressure(s). The containment of liquid means only prevention of escape of liquid through the external surfaces of the pumps, normally to atmosphere.

4.12.1 Method.

a. Testing will be performed in accordance with American National Standards Institute/Hydraulic Institute (ANSI /HI) 1.6-2000[29], paragraph 1.6.4, for centrifugal pumps and ANSI/HI 6.6-2000[30], paragraph 6.6.5, for reciprocating pumps.

b. The test items should have all openings adequately sealed. The items should then be filled with a test fluid, either water or oil, having a maximum viscosity of 32 Centistokes (150 Saybolt seconds Universal (SSU)) at test temperature, and then pressurized in accordance with the hydrostatic pressure specified in the PS.

c. The pressure should be maintained for a sufficient duration to permit a thorough examination of the parts under pressure. The test will be considered satisfactory when no leaks or structural failures are observed for a minimum of 3 min for pumps 75 kW (100 hp) and below, and 10 minutes for pumps above 75 kW (100 hp).

d. Special care must be taken to ensure that pressures in excess of 150 percent of design are not imposed on areas designed for lower pressure operation such as suction volutes, or mechanical seal areas of centrifugal pumps and inlet manifolds of reciprocating pumps.

e. Any leakage through the test item pump case or joints, or irreversible shape alterations that cause structural weakening, shall constitute a failure.

4.12.2 Data Required.

a. Identification by model, size, and serial number.

b. Test fluid identification and viscosity.

c. Maximum allowable working pressures and temperature.

d. Hydrostatic test pressure and test duration.

e. Date of test.

4.12.3 Data Presentation.

Working pressures and hydrostatic pressures applied for each pump tested will be presented in a table. Inspection results recorded in TIRs will be summarized in paragraphs or tables.

4.13 Pump Performance.

Before completing the following tests, the pump will be run under stable conditions for a sufficient length of time to bring about equilibrium and steady readings. If POL products are used as the test fluid, viscosity should be maintained within 10 percent of that specified for the duration of the test.

4.13.1 Method.

The test item will be operated in a level configuration with water as the test fluid and head-capacity data will be determined in accordance with ANSI/HI 1.6-2000, paragraphs 1.6.9 and 6.6.7, for centrifugal pumps and reciprocating pumps, respectively, and the results will be recorded. The PS may also require that the pump be tilted at certain orientation(s) to verify operation on sloped or uneven terrain.

4.13.2 Data Required.

a. Pump identification (model, size, and serial number).

b. Test system configuration (level or direction and angle of tilt), instrumentation, suction and discharge hose sizes and lengths, and position of the water source.

c. Test fluid temperature.

d. Ambient conditions (air temperature and barometric pressure).

e. System operating data (rate of flow, suction and discharge pressures).

4.13.3 Data Presentation.

System operating data and test results will be recorded and presented either in tables or in written paragraphs. The total dynamic head will be calculated by subtracting the suction head from the discharge head.

4.14 Priming Time (Self-priming Centrifugal Pump).

4.14.1 Method.

The pump priming test will be performed in accordance with ANSI/HI 1.6-2000, paragraph 1.6.8, for centrifugal pumps only. The static lift between the eye of the impeller or suction intake and the liquid level should not be less than 10 vertical feet, or that specified in the PS. The priming time is the total elapsed time between starting the unit and the time required to obtain a steady discharge gauge reading, or full flow through the discharge nozzle. This test is completed with water. The priming test is to be performed with the rated suction hose size. If a different size suction hose or pipe is employed for the test, the priming time conversion factor in paragraph 1.6.8.2 will be applied to calculate the true priming time.

4.14.2 Data Required.

a. Pump identification (model, size, and serial number).

b. Test configuration description and photographs (static lift measurement, suction and discharge hose sizes and lengths, discharge pressure gage location).

c. Water temperature.

d. Ambient conditions (air temperature and barometric pressure).

e. Fluid flow rate, suction and discharge pressures.

f. Time required for the pump to prime and produce a steady discharge flow.

4.14.3 Data Presentation.

Priming time results and system operating data will be summarized in paragraphs or tables.

4.15 Survivability.

4.15.1 HEMP.

HEMP testing will be coordinated with the Electromagnetic Pulse Facility, White Sands Missile Range (WSMR), New Mexico, or Electromagnetic Environments Branch, Naval Air Warfare Center (NAWC) Aircraft Division, Patuxent River, Maryland. The test officer should provide the pump PS to the WSMR or NAWC contact and request that he/she develop a test plan and report for the test efforts. The trained test officer and crew generally travel to the HEMP Test Facility to assemble, operate, and tear down the system. Testing for near-strike lightning (NSL), personnel electrostatic discharge (PESD), helicopter electrostatic discharge (HESD) and hazards of electromagnetic radiation to fuel (HERF) testing, if specified, would also be performed at

either WSMR or NAWC in a similar fashion as the HEMP testing outlined in the subparagraphs below.

4.15.1.1 Method.

a. Testing will be performed in accordance with MIL-STD-461E, Test Method RS105.

b. The pump will be operated in a closed loop with a large water source. System operating data will be recorded after each pulse to verify that all system components are fully functional before proceeding to the next scheduled pulse.

4.15.1.2 Data Required.

a. As listed in MIL-STD-461E, Test Method RS105.

b. System identification and test configuration.

c. System operating time, hr.

d. Output flow rate.

e. Physical inspection results

f. Repairs or maintenance performed to restore the pump to a fully functional state, recorded in TIRs.

4.15.1.3 Data Presentation.

a. As listed in MIL-STD-461E, Test Method RS105.

b. Inspection and operating results recorded in TIRs will be summarized in paragraphs or tables.

4.15.2 Chemical, Biological, and Radiological Contamination Survivability (CBRCS).

CBRCS testing is the responsibility of the West Desert Test Center (WDTC), U.S. Army Dugway Proving Ground (DPG), Utah. CBRCS testing can be conducted as a separate tasking from DTC and reported as a stand-alone document, or it can be incorporated as a subtest of the ATC test plan and report documents. The utility and fit of the contamination avoidance covers (CACs), if provided with the system, will be assessed by the test crew (paragraph 4.13.2c).

4.15.2.1 Method.

CBRCS can be addressed in three ways. The choice of method should be coordinated with the system developer and system evaluator.

a. The first method is testing of the system with a radiological stimulant, a biological stimulant, and chemical warfare agents. This testing produces actual data that allow the evaluator to determine if the system meets the DA-approved Nuclear, Biological, and Chemical (NBC) Contamination Survivability Criteria for Army Materiel[31] and Army Regulation (AR) 70-75[32]. Testing of the system will depend on the size of the system. Small items that can fit inside of a surety laboratory hood will be tested in accordance with TOP 08-2-111[33]. Larger systems will be tested in a surety chamber in accordance with TOP 08-2-510[34].

b. Testing of coupons of the system materials of construction can be performed. This testing will be conducted in accordance with TOP 08-2-061[35]. Data will be acquired on the effects of chemical agents and decontaminants used for chemical, biological, and radiological decontamination on the materials of construction tested. The effects of the contaminants and decontaminants on the system itself are nearly impossible to determine because of the issues of extrapolating data collected from small coupons to the 3-D surface of a system.

c. The third method of addressing CBRCS is to conduct a CBRCS Assessment (CBRCSA) (paper study). The CBRCSA is the expert opinion of the individual conducting the assessment on the expected ability of the system to meet the DA-approved NBC Contamination Survivability Criteria for Army Materiel. The CBRCSA report considers the system, the materials of construction, and any actual test data available on the materials.

4.15.2.2 Data Required.

As listed in TOPs 08-2-111, 08-2-510, or 08-2-061, coupon test method.

4.15.2.3 Data Presentation.

As listed in TOPs 08-2-111, 08-2-510, or 08-2-061, coupon test method.

4.16 Final Inspection.

4.16.1 Method.

After testing, test pump subsystems will be visually inspected and functionally checked. A summary of any damage or deterioration sustained and recommended corrective actions will be recorded and photographed. Any corrosion or material degradation will be denoted and photographed. The corrosion will be rated in accordance with the TACOM LCMC Corrosion Rating System.

4.16.2 Data Required.

a. Physical inspection and operational tests results.

b. Damage, deterioration, and corrosion photographs.

c. Corrective actions performed to remedy the defects.

4.16.3 Data Presentation.

Corrosion inspection results will be tabulated, and each location of corrosion will be classified. The final condition and operational test results will be summarized in a paragraph or tables and supported by photographs.

5. DATA REQUIRED.

Data required is listed throughout Section 4: Test Procedures.

6. PRESENTATION OF DATA.

Data presentation is listed throughout Section 4: Test Procedures.

APPENDIX A. TEST DATA FORMS.

Form A-1. Test Participant Demographic Data

Date: _____

Name: _____

Birth Date: _____

Age (years/months): _____

Military Rank: _____Civilian Job Description: _____

Years of Military Service: _____Years of Civilian Service: _____

Military MOS (number and description): _____

Time in service at current MOS: _____

Is this a primary or secondary MOS (circle one)? PRIMARY/SECONDARY

List the training you have completed in pump or other fluid delivery equipment: _____

_____

_____

_____

List the experience you have had with pump or other fluid delivery equipment (identify systems):

_____

_____

_____

APPENDIX A. TEST DATA FORMS.

Form A-2. NET Questionnaire

Evaluated By (Name): _____ Date: _____
(First) (M.I.) (Last) (Day) (Mo) (Yr)

Rank/Grade: _____ MOS/Job Title: _____ Experience: _____
(Yr) - (Mo)

Related Training: _____

_____

Related Experience: _____

_____

Instructions: Circle a number between the adjectives which best represents your opinion of the instruction you have received during this training period.

A. Instructor(s)

1.	Used jargon or confusing terms	Never	1	2	3	4	5	6	7	8	9	Always
2.	Speaking ability (enunciation, volume, etc.)	Poor	1	2	3	4	5	6	7	8	9	Excellent
3.	Subject knowledge	Poor	1	2	3	4	5	6	7	8	9	Excellent
4.	Treatment of students	Discourteous	1	2	3	4	5	6	7	8	9	Courteous
5.	Aware of student understanding	Never	1	2	3	4	5	6	7	8	9	Always
6.	Preparation of instruction	Poor	1	2	3	4	5	6	7	8	9	Excellent
7.	Response to student questions	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Overall rating	Unsatisfactory	1	2	3	4	5	6	7	8	9	Outstanding

B. Instruction:

1.	Basic concepts were defined at the beginning of each block of instruction	Never	1	2	3	4	5	6	7	8	9	Always
2.	Basic concepts were developed logically	Never	1	2	3	4	5	6	7	8	9	Always
3.	Presentation of material was	Boring	1	2	3	4	5	6	7	8	9	Interesting
4.	Classroom discussions were	Waste of time	1	2	3	4	5	6	7	8	9	Valuable
5.	Material was presented	Too slowly	1	2	3	4	5	6	7	8	9	Too rapidly
6.	Coverage of material was	Too basic	1	2	3	4	5	6	7	8	9	Too technical
7.	Training slides/presentation quality was	Poor	1	2	3	4	5	6	7	8	9	Excellent
8.	Training aids were used	Too seldom	1	2	3	4	5	6	7	8	9	Too often
9.	Lectures led into practical exercises	Never	1	2	3	4	5	6	7	8	9	Always

APPENDIX A. TEST DATA FORMS.

C. Practical Exercises or hands-on equipment experiences:

1.	Time scheduled for PE was	Inadequate	1	2	3	4	5	6	7	8	9	Adequate
2.	PEs were conducted on actual hardware	Never	1	2	3	4	5	6	7	8	9	Always
3.	All students participated in PEs	Never	1	2	3	4	5	6	7	8	9	Always
4.	PEs were conducted as scheduled	Never	1	2	3	4	5	6	7	8	9	Always
5.	What percentage of the instruction time was "hands on" for you?		10	20	30	40	50	60	70	80	90	

D. Lesson Assignments and References:

1.	Assignments were necessary	Never	1	2	3	4	5	6	7	8	9	Always
2.	Assignments were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
3.	Manuals and reference materials were	Too elementary	1	2	3	4	5	6	7	8	9	Too complicated
4.	Manuals and reference materials were designed for easy use	Never	1	2	3	4	5	6	7	8	9	Always

E. Examinations:

1.	Material covered in exams was presented during instruction/PE	Never	1	2	3	4	5	6	7	8	9	Always
2.	Exams were	Too short	1	2	3	4	5	6	7	8	9	Too long
3.	Exams were	Too simple	1	2	3	4	5	6	7	8	9	Too difficult
4.	Performance-type exams were given	Never	1	2	3	4	5	6	7	8	9	Always
5.	Exams tested knowledge of material presented during instruction/PE	Not at all	1	2	3	4	5	6	7	8	9	Completely

Please make any comments you desire. Suggested areas for comment are superior or unsatisfactory instruction, missing elements of instruction, questions you still have concerning system operation or maintenance but are not comfortable asking in a classroom setting, or recommended deletions to course content.

Form A-3. Pump Operating Data Sheet

System ID/Serial Number:________________ Operator Name: __________________
Date: ___________________ Next Scheduled PMCS:_____________ Test Scenario: _______________________

TIME, 24 HR	OPERATING TIME, hr	PRESSURE, psig		FLOW, gpm	FLUID TEMP, °F	COMMENTS
		INLET	DISCHARGE			

APPENDIX B. GLOSSARY.

Term	Definition
Centrifugal pump	A rotodynamic pump that uses a rotating impeller to increase the pressure of a fluid. Centrifugal pumps are commonly used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and is accelerated by the impeller, flowing radially outward into a diffuser or volute chamber (casing), from where it exits into the downstream piping system.
Datum	The reference line or center of the pump shaft from which all elevations are measured. The elevation head to the datum is positive when the gauge is above datum and negative when the gauge is below datum. The datum elevation for horizontal units is the centerline of the pump shaft. Datum elevation illustrations are available in ANSI/HI 1.6-2000, Figures 1.113 through 1.115.
Head	The expression of energy content of the liquid referred to a datum. It is expressed in units of energy per unit weight of liquid. The measuring unit is meter (feet) of liquid. The most common performance specification requirement is elevation head, which is measured from the surface of the liquid to the datum.
Rate of flow	Total volume throughput per unit of time at suction conditions. It assumes no entrained gases at the stated operating conditions.
Reciprocating pump	A positive displacement plunger pump. It is often used where a relatively small quantity of liquid is to be handled and where delivery pressure is quite large.
Speed	The number of revolutions of the shaft in a given unit of time. Speed is expressed as revolutions per minute.
Total discharge head	The reading of a pressure gage at the discharge of the pump, converted to feet (meters) of liquid and referred to datum plus the velocity head at the point of gage attachment.
Total head	The algebraic difference between the total discharge head and total suction head.
Total suction head	Reading of the gage at the suction of the pump converted to feet (meters) of liquid referred to datum plus velocity head at the point of gage attachment. Suction head exists when the total suction head is above atmospheric pressure.

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APPENDIX C. ABBREVIATIONS.

ANSI/HI	American National Standards Institute/Hydraulic Institute
AR	Army Regulation
AST	ATEC System Team
ATEC	U.S. Army Test and Evaluation Command
BII	basic issue items
CAC	contamination avoidance cover
CBRCS	chemical, biological, and radiological contamination survivability
CBRCSA	CBRCS Assessment
CDD	Capabilities Development Document
CG	center of gravity
CPD	Capabilities Production Document
DA PAM	Department of the Army Pamphlet
DPG	Dugway Proving Ground
DTC	US Army Developmental Test Command
EMC	electromagnetic compatibility
EMI	electromagnetic interference
EMITF	Electromagnetic Interference Test Facility
FM	Field Manual
HEMP	high-altitude electromagnetic pulse
HERF	hazards of electromagnetic radiation to fuel
HESD	helicopter electrostatic discharge
HFE	human factors engineering
HI	Hydraulic Institute
JHA	job hazard analysis
ICD	Initial Capabilities Document
ILS	integrated logistics support
IPR	In-Process Review
MHE	material-handling equipment
MIL-STD	Military Standard
MOPP	mission-oriented protective posture
MOS	military occupational specialty
MSDS	Material Safety Data Sheet

APPENDIX C. ABBREVIATIONS.

NAWC	Naval Air Warfare Center
NBC	nuclear, biological, and chemical
NET	new equipment training
NSL	near-strike lightning
OMS/MP	Operational Mode Summary/Mission Profile
PESD	personnel electrostatic discharge
pH	potential of hydrogen
POL	petroleum, oils, and lubricants
PS	Performance Specification
RFTS	Request for Test Services
RH	relative humidity
RITA	Repository Information and Test Analysis
SAE	Society of Automotive Engineers
SAR	Safety Assessment Report
SEP	System Evaluation Plan
SSU	Saybolt seconds Universal
SOW	Statement of Work
TACOM LCMC	U.S. Army Tank-automotive and Armaments Command
TIR	Test Incident Report
TM	Technical Manual
TOP	Test Operations Procedure
TSP	test support package
VDLS	VISION Digital Library System
VISION	Versatile Information Systems Integrated On-Line
WDTC	West Desert Test Center
WSMR	White Sands Missile Range

APPENDIX D. REFERENCES

Section I - Required Publications

1. MIL-STD-810G, Department of Defense Test Method Standard for Environmental Engineering Considerations and Laboratory Tests, 31 October 2008.

2. MIL-STD-461E, Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment, 20 August 1999.

3. MIL-STD-913A, Requirements for the Certification of Sling Loaded Military Equipment for External Transportation by Department of Defense Helicopters, 3 February 1997.

4. TOP 01-2-610, Human Factors Engineering, 15 May 1990.

5. TOP 02-2-612, Fording, 21 November 2007.

6. TOP 02-2-002, Dynamic Stability Handling And Steering 19 May 09.

7. DTC PAM 73-1, Developmental Test Guide, 30 October, 2006.

8. FM 10-52, Water Supply in Theaters of Operation, 11 July 1990.

9. FM 10-52-1, Water Supply Point Equipment and Operations, 18 June 1991.

10. FM 10-67, Petroleum Supply in Theaters of Operations, 18 February 1983.

11. FM 10-67-1, Concepts and Equipment of Petroleum Operations, 2 April 1998.

12. TOP 01-2-504, Physical Characteristics, 31 October 1972.

13. TOP 02-2-800, Center of Gravity, 26 September 2006.

14. TOP 02-2-801, Weight Distribution and Ground Pressure (Wheeled and Tracked Vehicles), 26 September 2006.

15. TOP 01-1-060, System Safety Engineering, 7 April 1986 (change 1 12 September 1986).

16. TOP 10-2-508, Safety and Health Hazard Evaluation - General Equipment, 6 May 1980.

17. MIL-STD-1472F, Department of Defense Design Criteria Standard Human Engineering, 23 August 1999.

18. DA PAM 385-16, System Safety Management Guide, 13 November 2008.

19. MIL-STD-1474D, Noise Limits, 12 February 1997.

APPENDIX D. REFERENCES

20. U.S. Army TACOM Life Cycle Management Command (TACOM LCMC) Corrosion Rating System.

21. TOP 01-2-621, Outdoor Sand and Dust Testing, 6 February, 2009.

22. TOP 06-2-542, Electromagnetic Interference Tests, 31 May 1994.

23. TOP 01-2-511, Electromagnetic Effects System Testing, 21 September, 2009.

24. TOP 01-2-500, Transportability, 15 September 2008.

25. SAE J2180, A Tilt Table Procedure for Measuring the Static Rollover Threshold for Heavy Trucks, 1 March 1993.

26. TOP 02-2-608, Braking, Wheeled Vehicles, 20 May 2008.

27. TOP 02-2-610, Gradeability and Side Slope Performance, 3 December 2009.

28. TOP 01-1-030, RAM-D and ILS Analysis, 8 September 2008.

29. ANSI/HI 1.6-2000, Centrifugal Pump Tests, 27 October 1999.

30. ANSI/HI 6.6-2000, Reciprocating Pump Tests, 25 February 2000.

31. Department of the Army (DA)-Approved NBC Contamination Survivability Criteria for Army Materiel, U.S. Army Nuclear and Combating Weapons of Mass Destruction Agency (USANCA), 30 May 2005.

32. AR 70-75, Survivability of Army Personnel and Materiel, 10 February 1995.

33. TOP 08-2-111, Nuclear, Biological and Chemical (NBC) Contamination Survivability, Small Items of Equipment, 24 April 1998.

34. TOP 08-2-510, NBC Contamination Survivability, Large Item Exteriors, 17 April 1998.

35. TOP 08-2-061, Decontaminating Apparatus, Portable, 19 November 2002.

Section II - Related Publications

a. Pump Handbook, Fourth Edition, McGraw Hill, 2008.

b. Hydraulic Institute Engineering Data Book, Second Edition, 1990.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to the following address: Test Business Management Division (TEDT-TMB), U.S. Army Developmental Test Command, 314 Longs Corner Road Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Support Equipment Division (TEDT-AT-WFE), U.S. Army Aberdeen Test Center. Additional copies can be requested through the following website: http://itops.dtc.army.mil/RequestForDocuments.aspx, or through the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.